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On-site Bioremediation of crude oil contaminated soil and water at ONG Dhansiri valley project at Jorhat

Prepared for Oil and Natural Gas Corporation Limited,
Jorhat

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(Banwari Lal, Vinod Kumar, Abu Swaleya and Samarjeet)

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Introduction

Oil spills are major menaces to the environment as they cause severe damage to surrounding ecosystems. During the Gulf War, several oil reservoirs were destroyed at sea, and the effect on marine life in their wake was devastating. Since crude oil is lighter than water, it floats on the sea surface and poses the threat of swift-spreading fire. Leave alone war time, oil spills are rather common in day to day activity of oil exploration companies at their drilling sites or at oil Group Gathering Stations.

Also, crude oil is transported to various processing units through a network of terrestrial pipelines. These pipelines can get damaged, spewing out crude oil over a large acreage.

The damage could be attributed to poor maintenance, sabotage by insurgent elements (as recently witnessed in Assam, India), or even theft. Oil spills on land pose a three-fold menace of (1) fire hazards, (2) groundwater pollution due to percolation, and (3) air pollution due to evaporation.

Apart from accidental crude oil spills, oily sludge, a hydrocarbon waste generated in huge quantity in crude oil storage tanks also creates environment pollution. Oil companies need a well planned oily sludge management strategy. A straightforward approach may be dumping the oily sludge into sludge pits. Since, the possibility of seepage cannot be ruled out, the ideal sludge pit should incorporate a leachate collection system and a polymer lining to prevent percolation of contaminants into the groundwater. Such pits are not only way too expensive, but also needed in large numbers. Since there is a limit to the area available within tank farm area, alternative solutions for eradication of oily sludge have to be sought.

Biological organisms, usually bacteria and fungi, and occasionally plants have been utilized to reduce/eliminate toxic pollutants. These microorganisms either eat up the contaminants (mostly organic compounds), or assimilate them (heavy metals), thus cleaning up the surrounding milieu. This biotechnological intervention – bioremediation – has been in use since the 1970s. It acquired global acceptance when the US Environmental Protection Agency and the Exxon Company demonstrated its effectiveness on Alaskan beaches contaminated by the *Valdez* oil spill.

After extensive research work, TERI has developed Oilzapper (crude oil and oily sludge degrading bacterial consortium) from various oil-eating bacterial cultures from the natural environment. These bacteria are multiplied under laboratory conditions, mixed with carrier materials, and packed into reusable polybags for convenient transportation. Utilizing Oilzapper to reclaim soil contaminated by crude oil spillage or oily sludge deposition is a very cost-effective and environmentally sound approach. The technique can be suitably modified to combat varying contaminants, as there is an immense diversity of bacteria to be tapped. The science of bioremediation thus acquires great significance in the area of research and development. Application of Oilzapper bacteria at IOCL's (Indian Oil Corporation Limited's) refineries and at Oil India Ltd., Duliajan's oil collection centre provided encouraging results, on the basis of which larger sites were taken up and soon completely reclaimed.

The aim of the present study is to demonstrate the potential of Oilzapper (crude oil/oily sludge degrading bacterial consortium) to reclaim the crude oil contaminated land and water at ONGC, Borhala oil field site.

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Bioremediation of crude oil spill at site 1 near Group Gathering Station

Methods

Mass scale production of Oilzapper: Crude oil degrading bacteria and its application at crude oil contaminated land and water

"*Oilzapper*" (a crude oil degrading bacterial system) production was done in a fermenter using minimal salt medium as nutrient for Oilzapper bacterial. After 16 hours growth of Oilzapper bacterial cultures were harvested and mixed with a carrier material. The carrier based Oilzapper (containing 10^{10} cells/g carrier material) was packed in sterilised polythene bags (Figure 1). Oilzapper culture packets were kept in dark at 25° C for 7 days for curing. Cured culture packets were transported to ONGC Dhansiri Valley project at Jorhat, and applied at bioremediation site 1 situated near GGS, bioremediation site 2 near GCP and bioremediation site 3 near cluster area at Borhala oil fields.

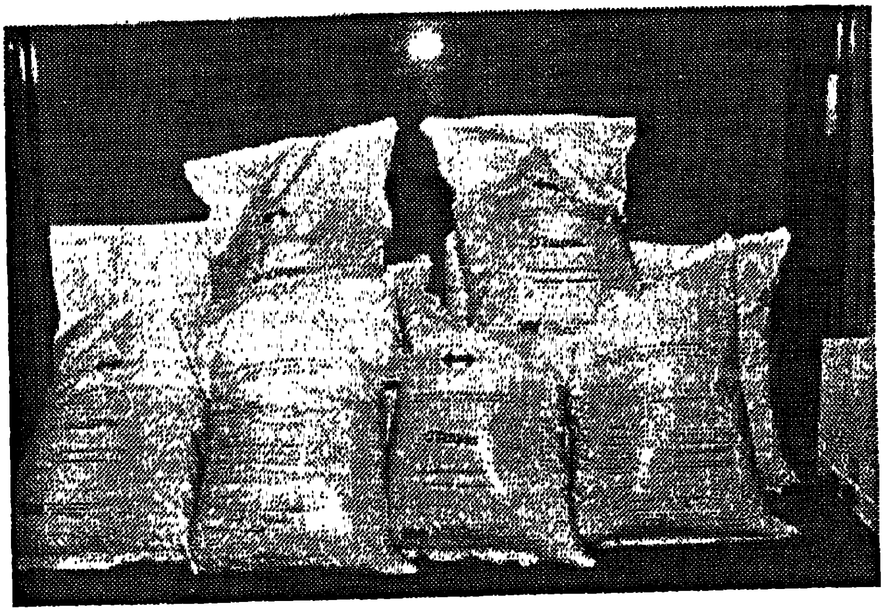

Figure 2.1 Oilzapper-A carrier based crude oil/oily sludge degrading bacterial consortium

Selection of sites for bioremediation of crude oil spill

Bioremediation of crude oil spill at ONGC, Jorhat was initiated in the month of October 2000. Three sites situated near Borhala oil field were selected for bioremediation of crude oil spill. Site 1 was situated near Group Gathering Station (GGS) as shown in Figure 2.2.

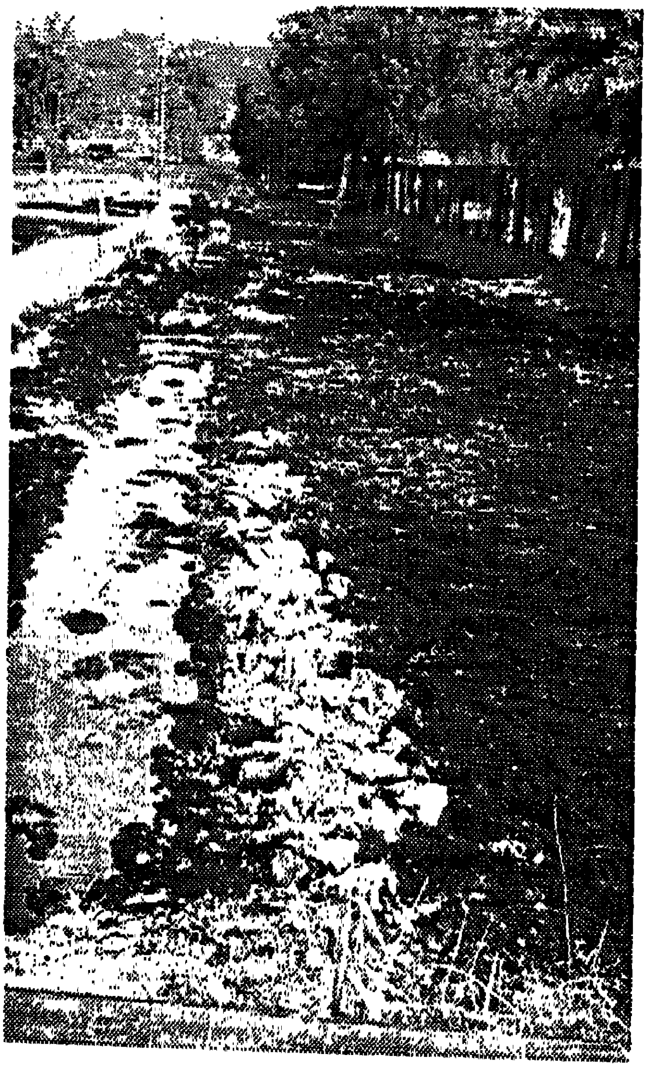

Figure 2.2 Bioremediation site 1 situated near GGS

Composition of crude oil biodegraded at bioremediation site 1 near Group Gathering Station

The crude oil collected from bioremediation site 1 situated near GGS was fractionated into alkane, aromatic asphaltene and NSO (nitrogen, sulphur and oxygen containing compound) by using a silicagel column. The crude oil was first dissolved in pentane and separated into soluble and insoluble fractions (asphaltenes). The soluble fraction was loaded on silicagel column and eluted with different solvents. The alkane fraction that was eluted with hexane, followed by the aromatic fraction that was eluded with toluven. The NSO fraction was eluted with chloroform and methanol. Alkane and aromatic fractions were concentrated by evaporation of solvents and then 0.2 µl of each was analysed by Gas chromatography (GC-FID Hewlett Packard, 5890 Series II) to identify all the compounds present in the alkane and aromatic fractions. In the alkane fraction, various alkane compounds were identified by matching the retention time with authentic standards. Simultaneously, the identification of each alkane compound was also confirmed by spiking the alkane fraction. A known amount of each standard alkane compound was added to the alkane fraction and injected into GC-FID (co-injection) and the peak area of each alkane compound increased as a result. Similarly, the polycyclic aromatic hydrocarbon compounds were identified by matching the retention time with an authentic standard and confirmed by spiking the sample with authentic standards.

Bioremediation of crude oil spill at site 1 situated near Group Gathering Station

The area of bioremediation site 1 was approximately 50 m x 30m. This site was fully saturated with crude oil due to continuous oil slick during unloading of tankers. At site 1, initially 150 Kg Oilzapper and 20 Kg nutrients was applied. In the month of February 2001, Oilzapper (150 Kg) was applied again at bioremediation site 1 near GGS. Just after application of Oilzapper and nutrient, tilling of site 1 was carried out manually for uniform mixing of bacteria in contaminated soil.

The sampling (10 samples) from bioremediation site 1 was carried out at zero time (just before application of Oilzapper) and after two, four and six months intervals. The samples were transported to the laboratory at TERI, New Delhi for analysis. Crude oil was heterogeneously distributed in the samples collected from bioremediation sites. Therefore, the sample were powdered by soil pulverizer, and then solvent extractable total petroleum hydrocarbon (TPH) from 10 g sample was extracted with hexane methylene chloride and chloroform (80 ml each) consecutively. After extraction, all three extracts obtained by hexane, methylene chloride and chloroform were pooled and dried at room temperature by evaporation of solvent under gentle nitrogen stream in a fumehood. After solvent evaporation, the amount of TPH recovered from 10 g sample collected from site 1 at zero time and after two, four and six months were determined by simple gravimetry. The difference in TPH concentrations in soil samples of zero time and after two, four and six months of initiation of bioremediation revealed the amount of crude oil (TPH) biodegraded at bioremediation site 1.

Biodegradation of various fractions of crude oil at site 1 near GGS

The TPH recovered from 10 samples collected from bioremediation site 1 at zero time and after two, four and six months were further fractioned into alkane, aromatic, NSO and asphaltene fractions on silicagel column as described above. The concentration of these fractions was estimated by gravimentry. The alkane and aromatic fractions of crude oil were also analysed by GC and degradation of these fractions was estimated by data obtained by GC analysis.

Results

Composition of crude oil biodegraded at site 1 near GGS

Before initiation of bioremediation of crude oil spill at site 1 near GGS the composition of crude oil was estimated. The composition of crude oil collected from GGS at zero time (before initiation of bioremediation) showed 63% alkane fraction, 25% aromatic fraction, 8% NSO fraction and 4% asphaltene fraction (Table 2.1).

Table 2.1 Composition of crude oil spilled at bioremediation site 1

Constituents of crude oil	(%)
Alkane fraction	63%
Aromatic fraction	25%
NSO fraction	8%
Asphaltene	4%

Biodegradation of crude oil at site1 near GGS

Bioremediation site 1 at GGS was heavily contaminated with crude oil due to continuous oil slick during unloading of tankers. Bioremediation of this site using Oilzapper was initiated in the month of October 2000 (zero time). At zero time contamination of crude oil in surface soil (surface to 25 cm depth) was 44.19%. Treatment of this site with Oilzapper resulted in reduction of crude oil contamination from 44.19%% to 13.45% in two months (December 2000) from 44.19% to 9.60% in four months (February 2001) and from 44.19% to 6.72% in six months (April 2001) which showed 69.56% biodegradation of crude oil in two months, 78.27% biodegradation in four months and 84.83% biodegradation in six months respectively (Figure 2.3).

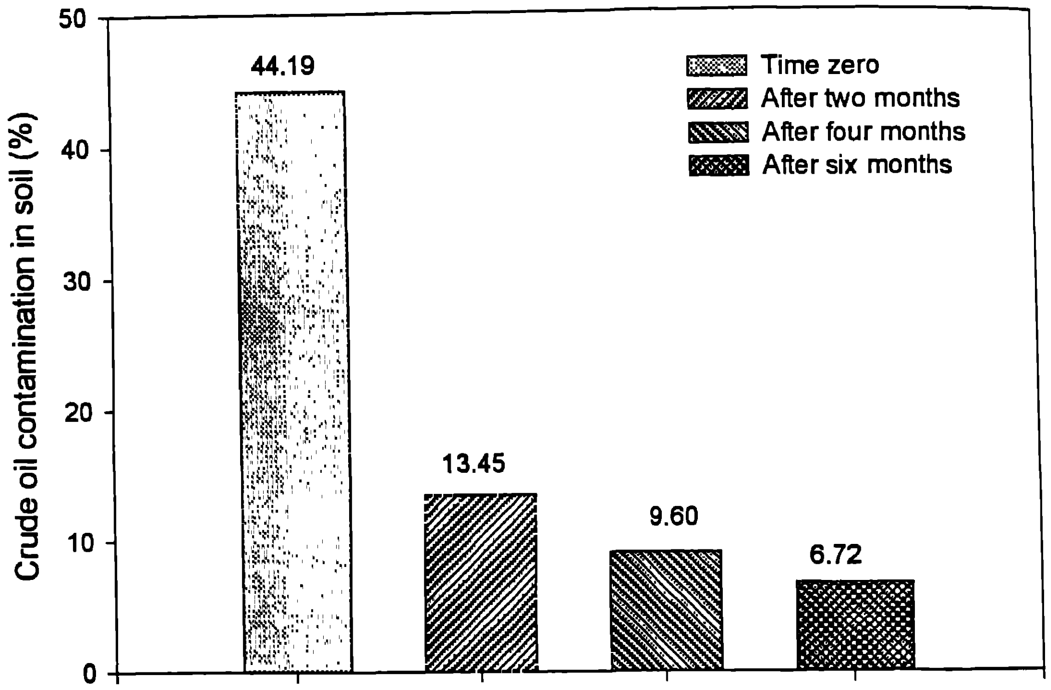

Figure 2.3 Bioremediation of crude oil contaminated soil at site 1

Biodegradation of various fractions of crude oil at site 1 near GGS

Biodegradation of various fractions of crude oil at site 1 was monitored. Of 84.83% biodegradation of crude oil in six months, biodegradation of alkane fraction was accounted for 58.32%%, aromatic fraction was for 21.44%, NSO fraction was for 2.30% and asphaltene fraction was 2.77% (Table 2.2). GC finger printing of biodegradation of alkane and aromatic fraction of crude oil in contaminated soil (25 cm horizon) are shown in figure 2.4 and 2.5 respectively.

Table 2.2 Biodegradation of various fractions of crude oil at bioremediation site 1 near GGS

Crude oil fractions	Biodegradation in six months (%)
Total petroleum hydrocarbons	84.83
Alkane fraction of crude oil	58.32
Aromatic fraction of crude oil	21.44
NSO fraction of crude oil	2.30
Asphaltene fractions of crude oil	2.77

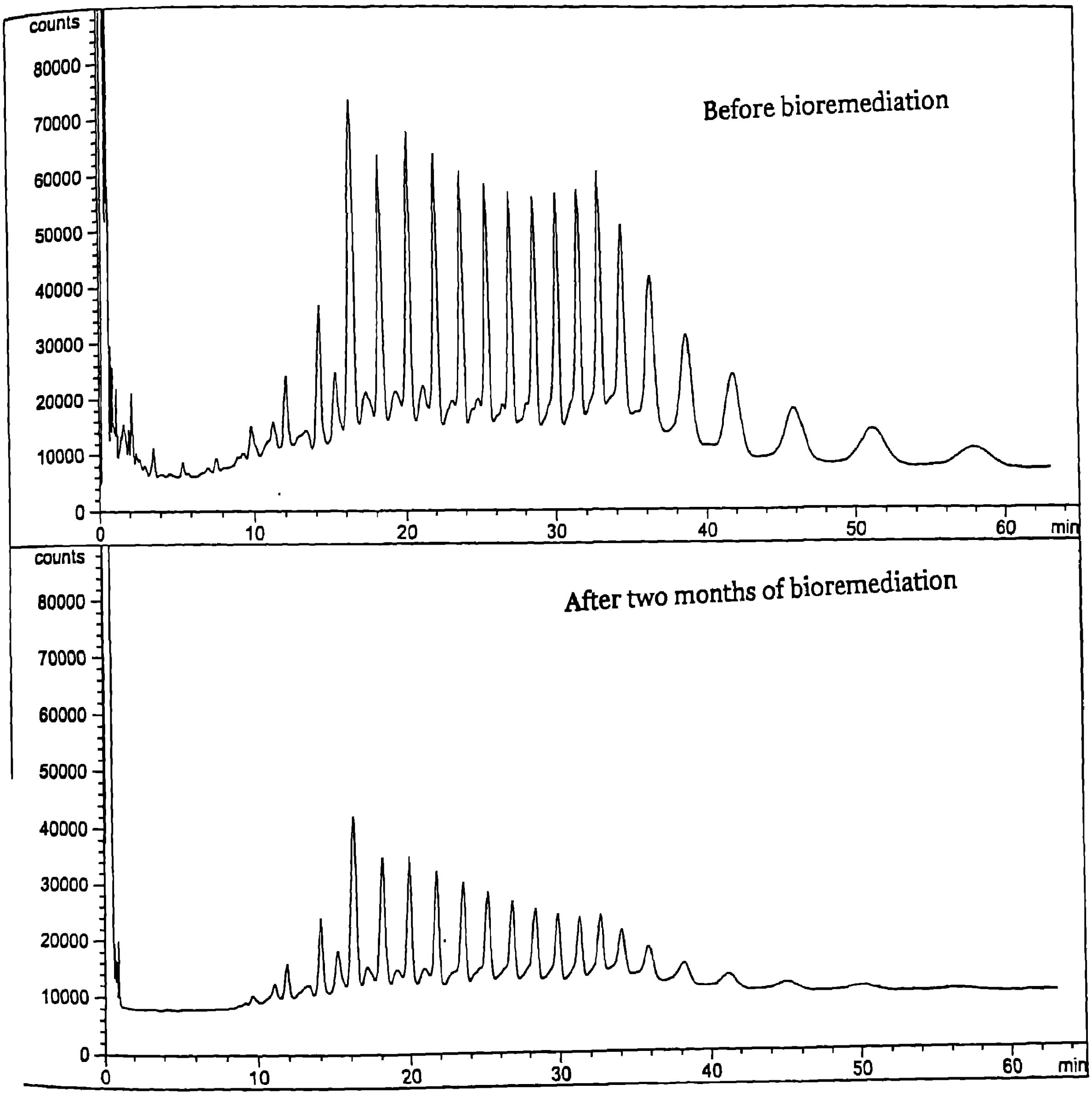

Figure 2.4 GC Fingerprinting of biodegradation of alkane fraction of crude oil at site 1

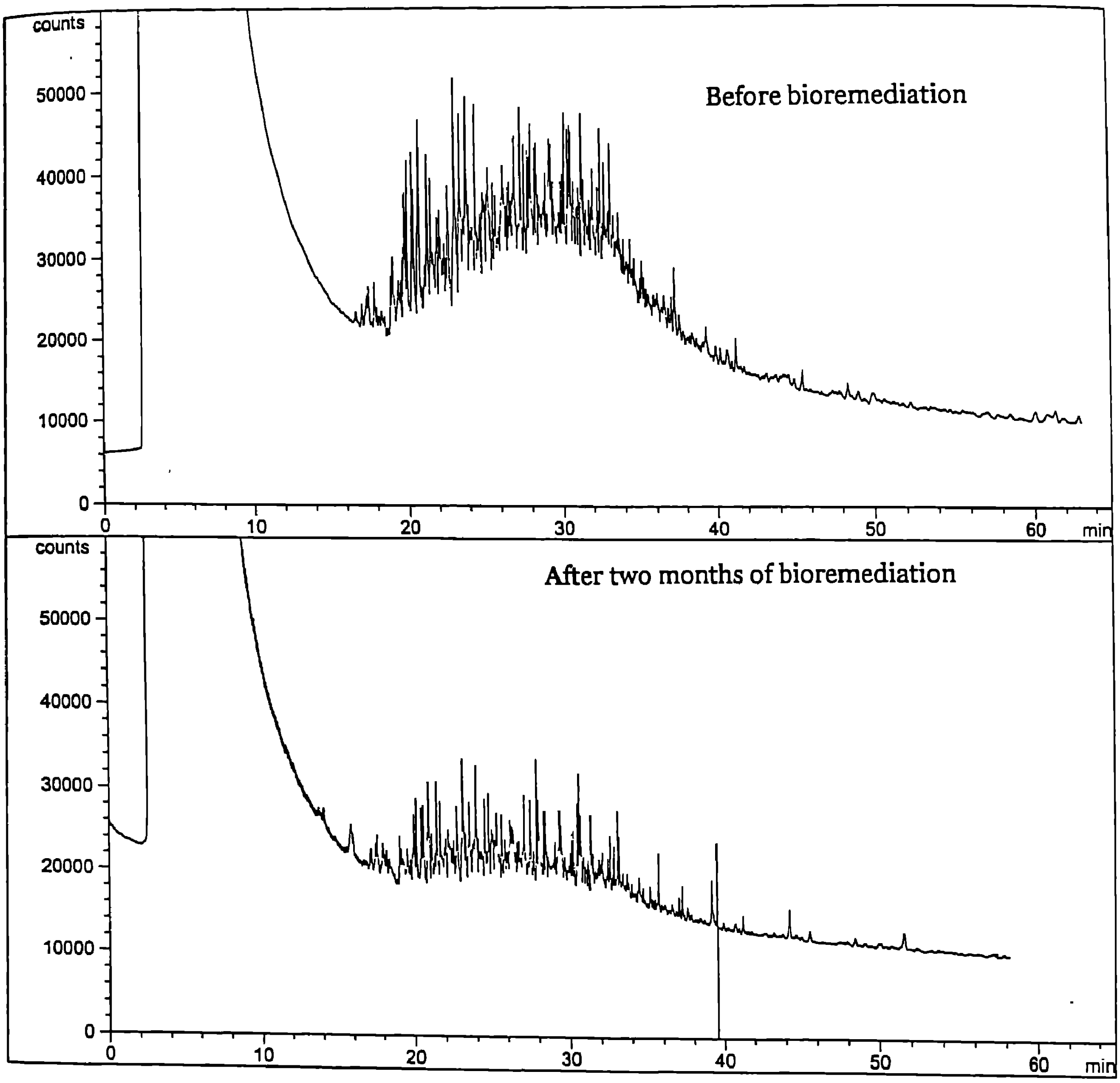

Figure 2.5 GC Fingerprinting of biodegradation of aromatic fraction of crude oil at site 1

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Bioremediation of crude oil spill at site 2 situated near GCP

Methods

Selection of site

Crude oil spill site 2 situated near Compressed Gas Plant (GCP) was selected for bioremediation using Oilzapper (Crude oil degrading live bacteria as shown in Figure 2.1). Land was contaminated with crude oil due to pipeline leak as shown in Figure 3.1. This site was fully saturated with crude oil and crude oil was floating on surface land, which may cause fire hazard. In the month of October, 2000 this site was undertaken for clean up using Oilzapper.

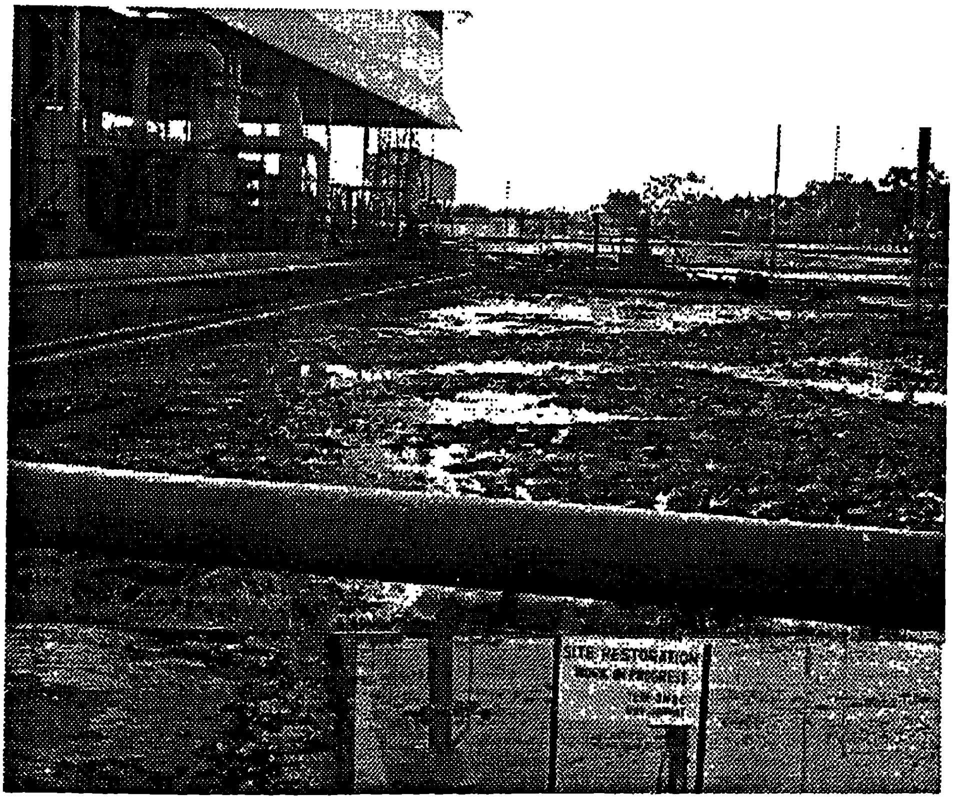

Figure 3.1 Bioremediation site 2 situated near GCP

Composition of crude oil biodegraded at bioremediation site 2 near GCP

The crude oil collected from bioremediation site 2 situated near GCP was fractionated into alkane, aromatic asphaltene and NSO (nitrogen, sulphur and oxygen containing compound) with a silicagel column. The crude oil was first dissolved in pentane and separated into soluble and insoluble fractions (asphaltenes). The soluble fraction was loaded on silicagel column and eluted with different solvents. The alkane fraction was eluted with hexane, followed by the aromatic fraction eluded with toluene. The NSO fraction was eluted with chloroform and methanol. Alkane and aromatic fractions were concentrated by evaporation of solvents and then 0.2 µl of each was analysed by Gas chromatography (GC-FID Hewlett Packard, 5890 Series II) to identify all the compounds present in the alkane and aromatic fractions. In the alkane fraction, various alkane compounds were identified by matching the retention time with authentic standards. Simultaneously, the identification of each alkane compound was also confirmed by spiking the alkane fraction. A known amount of each standard alkane compound was added to the alkane fraction and injected into GC-FID (co-injection) and the peak area of each alkane compound increased as a result. Similarly, the polycyclic aromatic hydrocarbon compounds were identified by matching the retention time with an authentic standard and confirmed by spiking the sample with authentic standards.

In situ bioremediation of crude oil spill at site 2 near GCP

The area of crude oil spill at site 2 was approximately 50 m x 50 m. At this site 50 Kg Oilzapper was applied in the month of October 2000. In the month of December 2000, Oilzapper (100 Kg) was applied again. Just after application of Oilzapper, tilling of site was carried out manually at periodic intervals for uniform mixing of Oilzapper bacteria in crude oil contaminated soil. Soil samples (10 samples) were collected from site 2 at zero time (just before initiation of bioremediation) after two, four and six months of initiations of bioremediation. Crude oil contaminated soil samples were collected from surface to 25 cm depth using soil sampler (hollow pipe). Samples were transported to the TERI laboratory at New Delhi for analysis. Crude oil was extracted from 10 g soil samples collected at zero time and after two, four and six months of initiation of work. Samples (10 g crude oil contaminated soil samples) were taken in 100 ml flasks and added 50 ml hexane in each flask containing 10 g sample. These flasks were kept on a rotary shaker at 37° C for six hours. After incubation these flasks were kept overnight for settle down of soil. Next day, crude oil dissolved in hexane was taken out in evaporating discs. Hexane (50 ml) was added again in these flasks and incubated at 37° C on a shaker as mentioned above. After settle down of soil crude oil (dissolved in hexane) was taken out in the evaporating discs. This step was repeated using different solvents (methylene chloride and chloroform) till complete extraction of crude oil from crude oil contaminated soil samples.

After complete extraction of crude oil from soil samples, evaporating discs (containing crude oil in solvents) were kept in a fumehood for evaporation of solvents. After solvent evaporation, the amount of TPH recovered from 10 g soil samples were estimated by taking the weight of recovered crude oil. Thus the reduction of crude oil concentration in surface oil (surface to 25 cm depth) at different time period during bioremediation revealed biodegradation of crude oil.

Biodegradation of various fractions of crude oil at site 2

Biodegradation of various fractions of crude oil in soil at site 2 was estimated as described in chapter 2. Crude oil recovered from 10 g crude oil contaminated soil samples was fractionated into aliphatic (alkane), aromatic, NSO (nitrogen, sulphur, oxygen containing compounds) and asphaltene fractions by silicagel column. Crude oil recovered from 10 g soil samples was first fractionated into various fractions using silicagel column as described above. After evaporation of solvents the alkane and aromatic fractions were analysed by GC.

Results

Composition of crude oil biodegraded at site 2 near GCP

Composition of crude oil biodegraded at site 2 near GCP was estimated by fraction of crude oil by silicagel column. The composition of crude oil biodegraded at site 2 near GCP revealed that crude oil contained 65% aliphatic fraction (alkane), 20% aromatic fraction, 12% NSO fraction and 3% asphaltene fraction (Table 3.1). Composition of crude oil spilled at site 2 was different from composition of crude oil spilled at site 1. Crude oil spilled at site 2 contained more of NSO fraction and less of aromatic fraction as compared to crude oil spilled at site 1 near GGS.

Table 3.1 Composition of crude oil spilled at site 2 near GCP

Constituent of crude oil	(%)
Alkane fraction	65
Aromatic fraton	20
NSO fraction	12
Asphaltene fraction	3

Biodegradation of crude oil at site 2 near GCP

Site 2 was contaminated with crude oil due to oil slick. Site 2 was also undertaken for bioremediation using live crude oil degrading bacteria known as "Oilzapper". At zero time (before treatment of site 2 with Oilzaper) crude oil contamination in 25 cm horizon soil (from surface to 25 cm depth in soil) was 34.60% treatment of this site with Oilzapper resulted that crude oil contamination in 25 cm horizon soil reduced from 34.60% to 3.64% in two months, from 34.60% to 2.75% in four months and from 34.60% to 0.92% in six months which exhibited 84.4% biodegradation in two months, 92% biodegradation in four months and 97.34% biodegradation in six months (Figure 3.2).

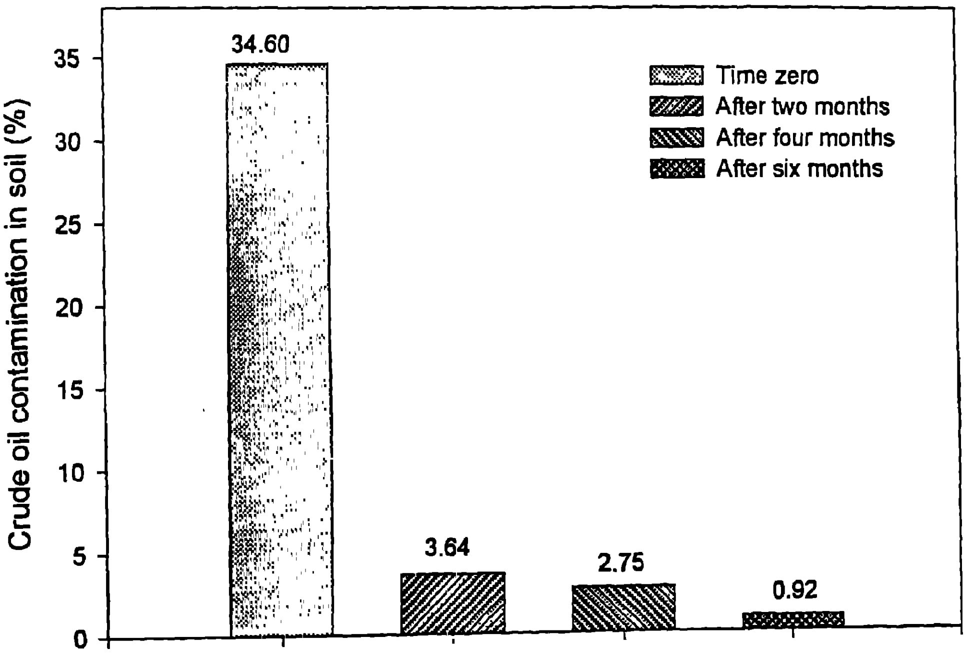

Figure 3.2 Bioremediation of crude oil contaminated soil at site 2

Biodegradation of various fractions of crude oil at site 2

Biodegradation of various fractions of crude oil in 25 horizon soil was estimated by analysis of various fractions of crude oil. Out of 97.34 biodegradation of crude oil in six months, biodegradation of alkane fraction was 64.32%, aromatic fraction was 19.10%, NSO fraction was 11.2% and asphaltene fraction was 2.72% (Table 3.2).

Table 3.2 Biodegradation of various fraction of crude oil in contaminated soil at site 2

Fractions of crude oil	Biodegradation in six months (%)
Alkane fraction of crude oil	64.32
Aromatic fration of crude oil	19.10
NSO fraction of crude oil	11.20
Asphaltene fraction of crude oil	2.72

GC finger printing of biodegradation of alkane and aromatic of crude oil in contaminated soil at site 2 are shown in figure 3.3 and 3.4 respectively.

Surface soil at site 2 near GCP was completely black and at zero time no vegetation was existed at this site. Just after two months treatment of this site with Oilzapper resulted sprouting of grasses in soil as shown in figure 3.4 and after six months, land turned into its original state.

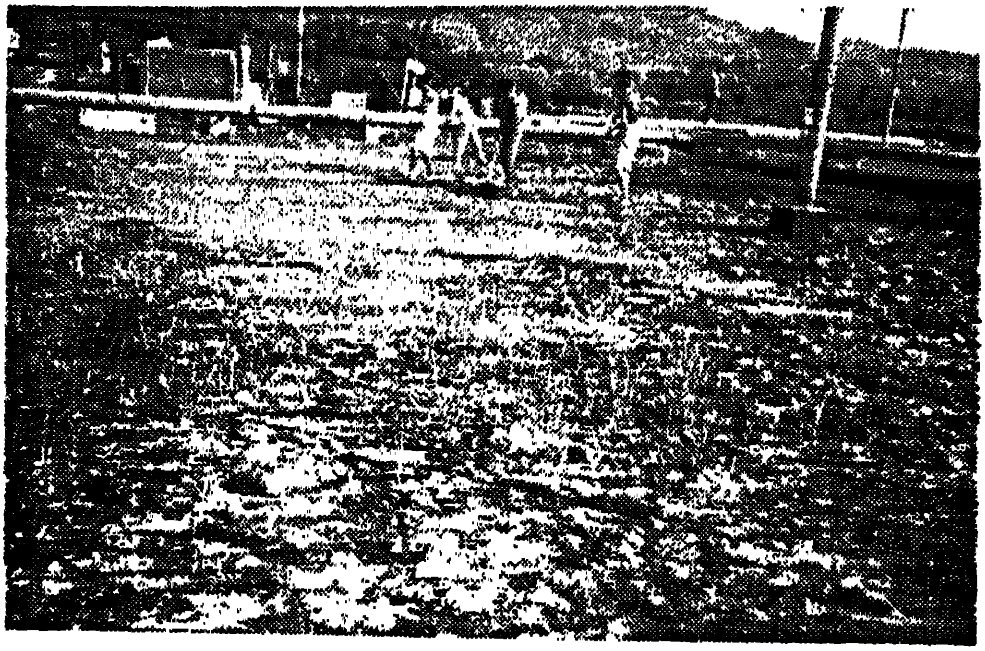

Figure 3.5 Bioremediation of site 2 (After two months by Oilzapper)

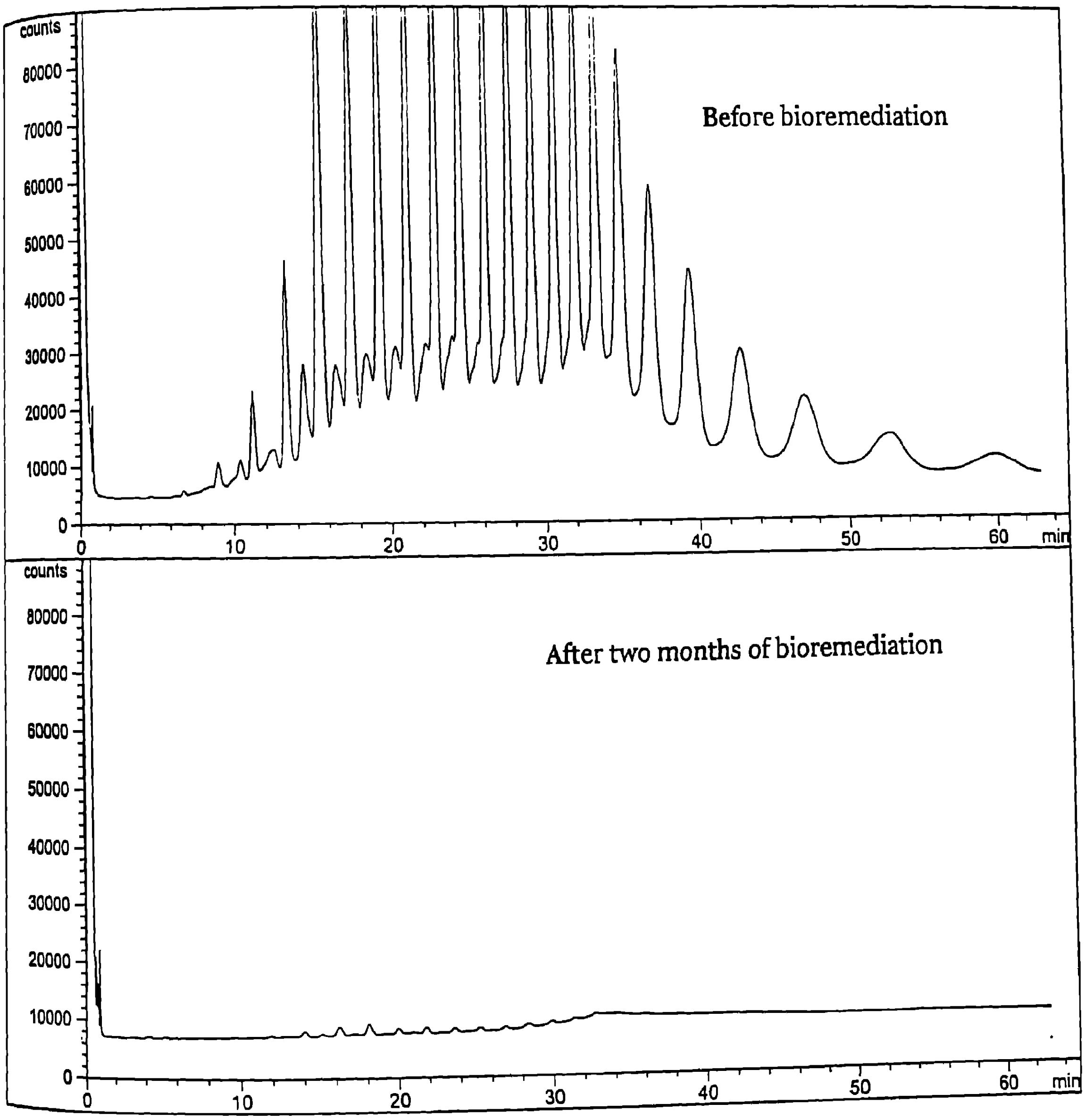

Figure 3.3 GC Fingerprinting of biodegradation of alkane fraction of crude oil at site 2

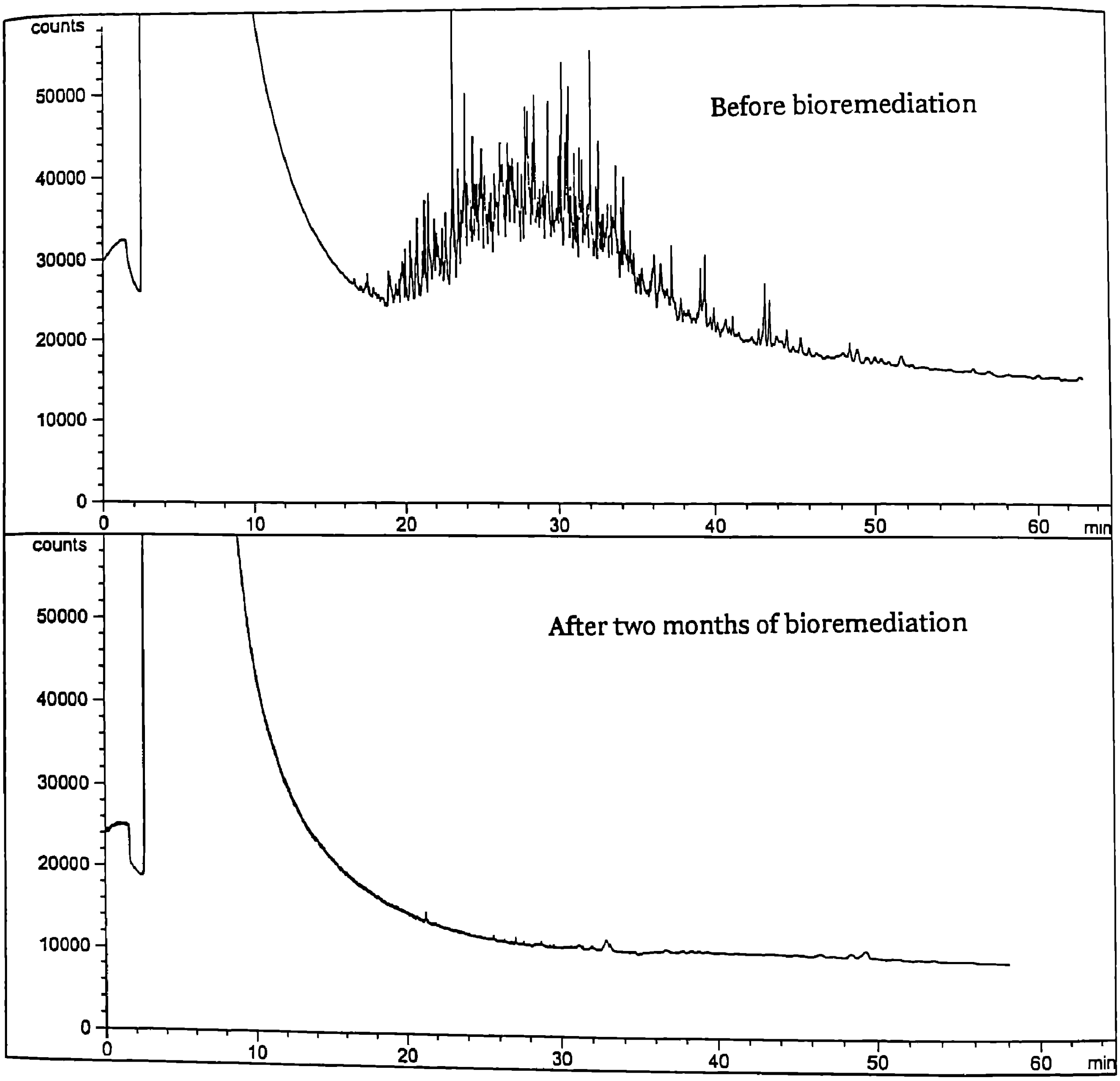

Figure 3.4 GC Fingerprinting of biodegradation of aromatic fraction of crude oil at site 2

4

Bioremediation of crude oil contaminated water in a pit situated in cluster area

Selection of site

A water pit containing waxy heavy oil floating water was selected for bioremediation. This pit was situated in cluster area. Depth of this pit was more than 10 feet. More than one feet thick layer of waxy crude oil was floating on surface water (Figure 4.1). Oilzapper 150 Kg was applied on waxy heavy crude oil and mixing was done by using bamboo stick.

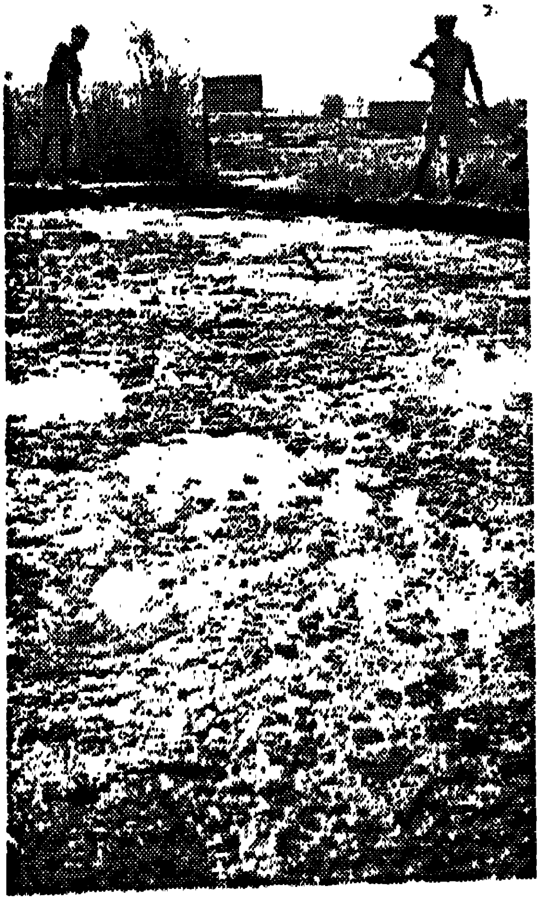

Figure 4.1 Bioremediation site 3 situated in cluster area

Composition of crude oil biodegraded in a pit

Composition of waxy crude oil biodegraded in water pit was estimated. At zero time (before mitiation of bioremediation of crude oil) samples were collected. Crude oil samples were heated at 60-70^0 C and water from crude oil was separated by using separating tunnel. After separation of water from crude oil a known weight of crude oil (1 g) was dissolved in pentane and separated into soluble and insoluble fractions (asphaltenes). The soluble fraction was loaded on silicagel column and eluted with different solvents. The alkane fraction was eluted with hexane, followed by the aromatic fraction was eluded with toluvene. The NSO fraction was eluted with chloroform and methanol. Alkane and aromatic fractions were concentrated by evaporation of solvents and then 0.2 µl of each was analysed by Gas chromatography (GC-FID Hewlett Packard, 5890 Series II) to identify all the compounds present in the alkane and aromatic fractions. In the alkane fraction, various alkane compounds were identified by matching the retention time with authentic standards. Simultaneously, the identification of each alkane compound was also confirmed by spiking the alkane fraction. A known amount of each standard alkane compound was added to the alkane fraction and injected into GC-FID (co-injection) and the peak area of each alkane compound increased as a result. Similarly, the polycyclic aromatic hydrocarbon compounds were identified by matching the retention time with an authentic standard and confirmed by spiking the sample with authentic standards.

Bioremediation of crude oil contaminated water in a pit

A water pit containing more than one feet thick layer of waxy crude oil was selected for bioremediation. Samples (10 samples) were collected from this pit at zero time and after two, four and six months intervals. Samples were transported to TERI at New Delhi for analysis. Solvent extractable total petroleum hydrocarbon from 10 g sample was extracted using hexane, methylene chloride and chloroform as described in chapter 2 and 3. Samples (10 g) were taken in flasks and added hexane in these flasks. After proper mixing of oil in hexane, top layer of hexane containing crude oil was separated by using separating tunnel. Crude oil recovered from 10 g samples collected at zero time and after two, four and six months intervals were quantified. Thus the reduction of crude oil in samples from zero time to different time intervals exhibited biodegraded crude oil in water pit.

Estimation of biodegradation of various fractions of crude oil in water pit

Crude oil recovered from 10 g samples collected at zero time and after different time intervals was fractionated into alkane, aromatic, NSO and asphaltene fractions using silicagel column. Thus concentration of alkane, aromatic, NSO and asphaltene fractions in crude oil was estimated by gravimetry. After quantification of each fractions, alkane and aromatic fractions of crude oil were analysed by Gas chromotography for estimation of degradation of various alkane and aromatic compounds.

Results

Composition of crude oil biodegraded at site 3 situated in cluster

One water pit containing more than one feet thick layer of oil was undertaken for bioremediation. At zero time (before Oilzapper treatment) composition of crude oil floating on surface water in pit revealed that crude oil constituted 67% alkane fraction, 21% aromatic fraction, 4% NSO fraction and 8% asphaltene fraction (Table 4.1).

Table 4.1 Composition of crude oil biodegraded at site 3 situated in cluster area

Constituent of crude oil	(%)
Alkane fraction	67
Aromatic fraction	21
NSO fraction	4
Asphaltene fraction	8

Bioremediation of crude oil contaminated water in a pit situated in cluster area

Bioremediation of water contaminated with heavy waxy crude oil was undertaken in the month of October 2000. At zero time the solvent extractable total petroleum hydrocarbon in (TPH) waxy heavy crude oil was 46.20%. treatment of this waxy heavy oil by Oilzapper resulted that solvent extractable TPH in oil reduced from 46.20 to 35.82% in two months, from 46.20 to 32.25% in four months and from 46.20% to 22.40% in six months which revealed 2.46%, 30.19% and 31.38% biodegradation of TPH in two, four and six months respectively (Figure 4.2).

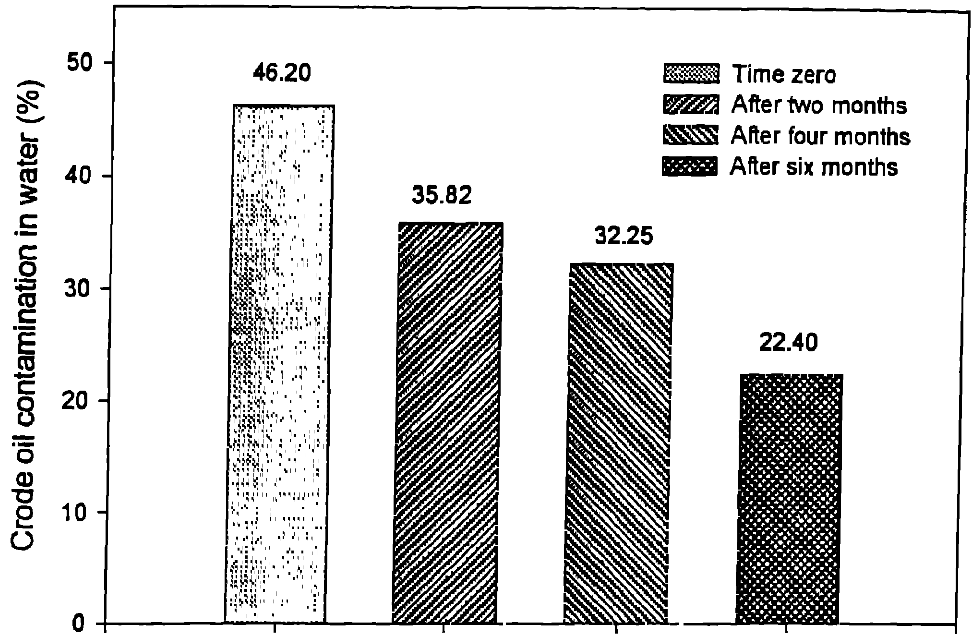

Figure 4.2 Bioremediation of crude oil contaminated water at site 3

Bioremediation of various fraction of waxy heavy oil

Biodegradation of various fractions of waxy oil floating on water in pit was monitored by gas chromatography analysis of various fractions of crude oil. Of 51.38% biodegradation of TPH in six months, biodegradation of alkane fraction was accounted 38.40% aromatic fraction was 10.60%, NSO fraction was 1.1% and asphaltene fraction was 1.28% in six months (Table 4.2). Biodegradation of alkane and aromatic fractions of crude oil are shown in Figures 4.3 and 4.4 respectively.

Table 4.2 Biodegradation of various fractions of crude oil at site 3

Fractions of crude oil	Biodegradation in six months (%)
Total Petroleum hydrocarbon	51.38
Alkane fraction	38.40
Aromatic fraction	10.60
NSO fraction	1.10
Asphaltene fraction	1.28

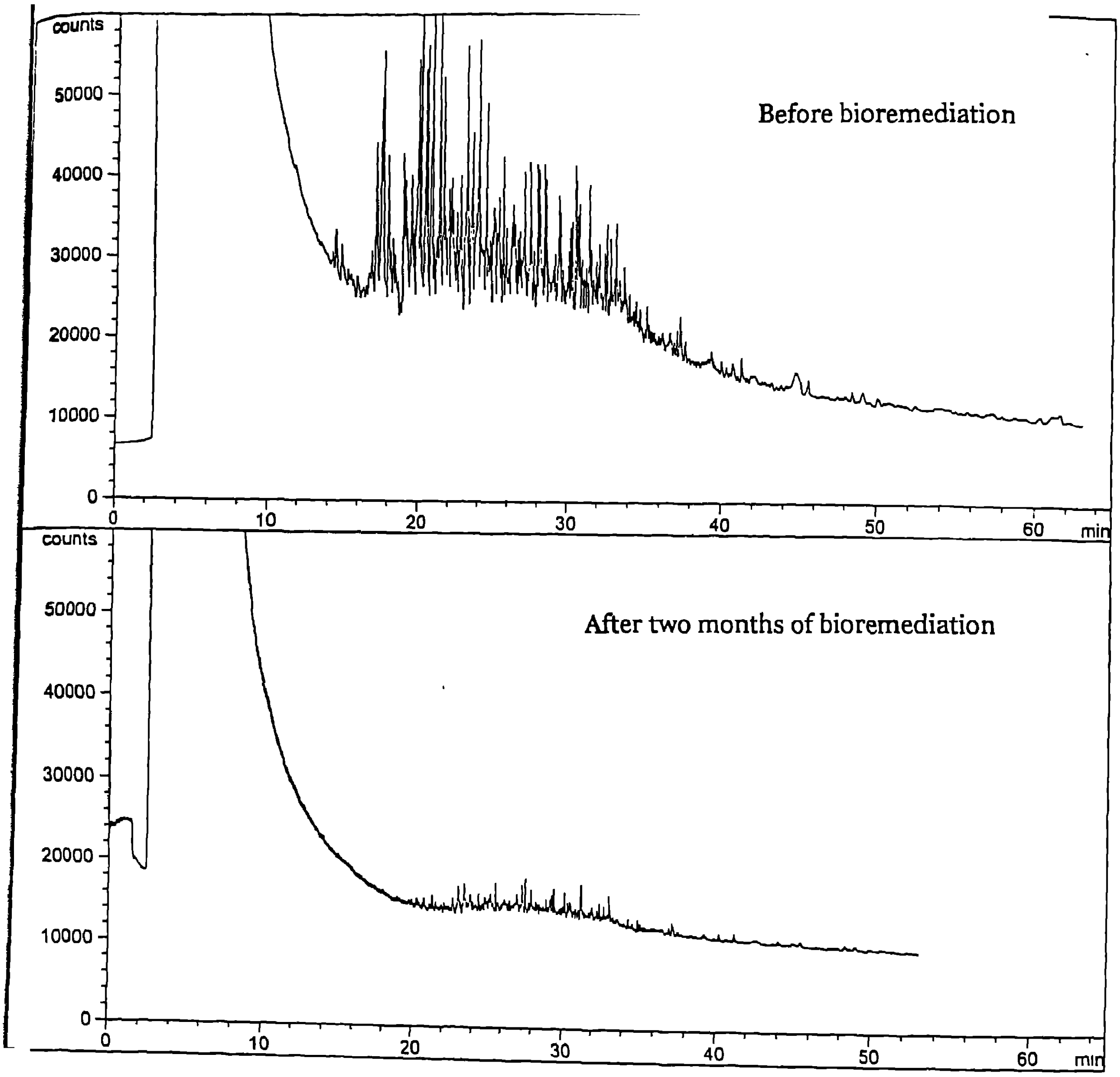

Figure 4.3 GC Fingerprinting of biodegradation of alkane fraction of crude oil at site 3

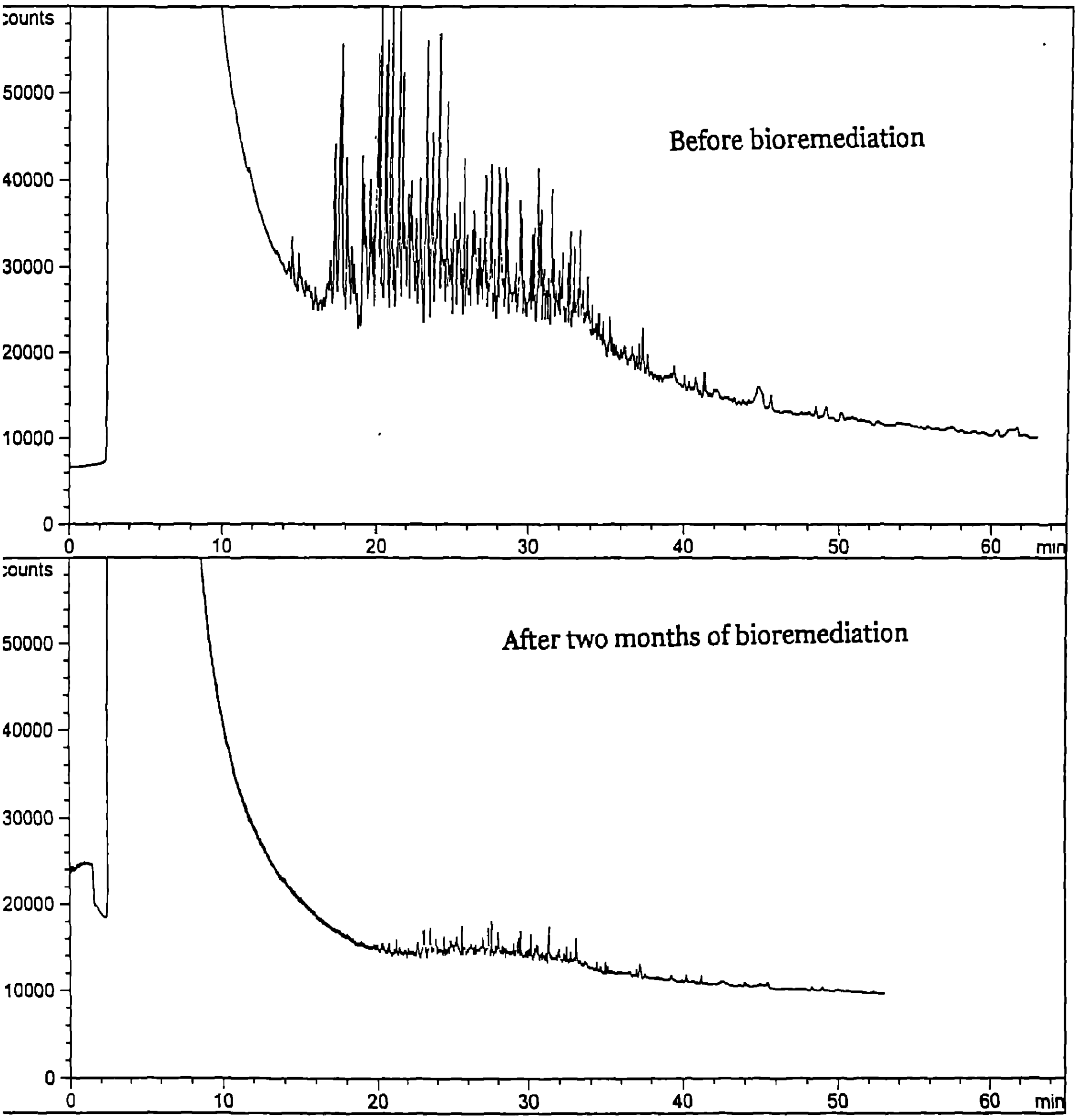

Figure 4.4 GC Fingerprinting of biodegradation of aromatic fraction of crude oil at site 3

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Summary

- Bioremediation of crude oil spills on land and water was initiated at ONGC Dhansiri Valley project, Jorhat in the month of October 2000. Three sites were selected for bioremediation. Site 1 was situated near GGS. Site 2 was situated near gas compressed plant and site 3 was situated in the cluster area. Site 1 and 2 were land contaminated sites, while site 3 was a water contaminated site. The composition of crude oil slick at site 1, site 2 and site 3 were almost similar.
- At bioremediation site 1, the crude oil contamination in soil was 44.19% in the month of October 2000. Treatment of this site with Oilzapper resulted the reduction of crude oil contamination in soil from 44.19% to 6.72% in six months, which exhibited 84.83% biodegradation of crude oil, the degradation of alkane fraction of crude oil was 58.32%, aromatic fraction of crude oil was 21.44%, NSO fraction was 2.30% and asphaltene fraction was 2.77% recorded in six months.
- At bioremediation site 2, the crude oil contamination in soil was 34.60% in the month of October 2000. With application of Oilzapper at this site, resulted that the crude oil contamination in soil reduced from 34.60% to 0.92% in six months, which revealed 97.39% biodegradation of crude oil in six months. Biodegradation of alkane, aromatic, NSO and asphaltene fractions of crude oil at site 2 was recorded 64.32%, 19.10%, 11.20% and 2.72% respectively in six months.
- Treatment of crude oil contaminated water by Oilzapper at this site 3 revealed that thick layer of crude oil floating on surface water was broken down into small pieces and clear water was visible in two months. At zero time the TPH content in waxy heavy crude oil floating on water surface was 46.20%. Treatment of this waxy crude oil by Oilzapper resulted that TPH content in waxy crude oil reduced from 44.20% to 22.40% in six months which showed 51.38% biodegradation of TPH in six months.

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Recommendations

Oil spills are major menaces to the environment as they cause severe damage to surrounds. Oil spills are common at oil well sites during tanker loading and at GGS. Also, crude oil is transported to various processing units through a network of terrestrial pipelines. These pipelines can get damaged spewing out crude oil over a large acreage. Such crude oil spills can be cleaned up by using a bacterial consortium known as Oilzapper, which can biodegrade crude oil at very fast rates. With application of Oilzapper large area of crude oil spills on land and water have been cleaned up. Similarly bioremediation of crude oil contaminated land and water using Oilzapper have been successfully demonstrated at ONGC Dhansari Valley project near Borhala.

Clean up of crude oil spill sites by using Oilzapper is cost effective and environment friendly approach. Now ONGC may use Oilzapper at large scale for bioremediation of crude oil contaminated water and land. Oilzapper material is readily available at TERI, New Delhi.